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THE
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APRIL-MAY, 1899

THE VARIATION OF GLACIERS. IV¹

THE following is a summary of the third annual report of the International Committee on Glaciers.²

RECORD OF GLACIERS FOR 1897

Swiss Alps.—The glaciers of this region are in general in a state of retreat. Of fifty-six glaciers observed, thirty-nine are retreating; five are stationary; twelve are advancing.

Two glaciers have been under observation during a complete period, the Zigiorenove and the Trient. The Zigiorenove had a maximum in 1852; it retreated from then until 1878 (twenty-six years); it then advanced until 1896 (eighteen years), when it had another maximum. Hence its entire period from maximum to maximum amounted to forty-four years.

The Trient had a maximum in 1845; from that time it

¹ The first three articles of this series appeared in this JOURNAL, Vol. III, pp. 278-288; Vol. V, pp. 378-383, and Vol. VI, pp. 473-476.

² Archives des sciences phys. et nat., Vol. VI, pp. 52-84, Geneva, 1898. At the meeting of the International Committee on Glaciers, in St. Petersburg, on September 1, 1897, Professor Ed. Richter was elected president, and Professor Finsterwalder, secretary, for the following three years. The following investigators were elected corresponding members of the committee: Professor Torquato Taramelli, Pavia; Dr. Thoroddsen, Reykiavik, Iceland; Baron Gerard de Geer, Stockholm; Constantin Rossikow, Wladikavkas; Professor Dr. Sapojnikow, Tomsk; Dr. A. Hamberg, Stockholm; M. Lipski, St. Petersburg; Professor Israel C. Russell, Ann Arbor, Mich.; M. I. Coaz, Bern; M. Chas. Rabot, Paris.

retreated until 1878 (thirty-three years); it then advanced until 1896 (eighteen years), when it had another maximum, which makes its entire period fifty-one years.

There remain still among the Swiss glaciers some marks of the increase of the last quarter of the nineteenth century, but the retreat of the glaciers is now, very generally, in full force.¹

Eastern Alps.—The important results obtained during the current year in the eastern Alps justify the labor undertaken to obtain them. It has been shown that the partial advance observed since 1885 extends towards the east beyond the Brenner, even as far as the groups of the Venediger and the Glockner; and it is most probable that this is not the result of the great precipitation during the past two years, but is due to some more general cause; for it has been possible to predict it in the case of the Gliederferner since 1892. This same glacier has also given us some information in answer to the question—does the swelling of a glacier move down the glacier more rapidly than the rate of flow of the ice? The reply is affirmative. From 1887 to 1892 the ice had moved a distance of 110 meters, whereas the swelling had advanced 250 meters. When the swelling reached the point at which the velocity was measured, it produced a considerable increase in the velocity of the ice. Similar results are also found with the Vernagtferner.

Of these glaciers we have, definitely, twenty-six advancing, eight stationary, and twenty-six retreating. The retreat seems to be more general as we go further eastward.²

Italian Alps.—No results are given for these glaciers, but a careful report is made of the means taken for marking their positions, so that in the future the variations of a large number may be determined.

Scandinavian Alps.—So far as observations go, the glaciers in this region are either stationary or retreating.³

¹ F. A. FOREL, XVII Rapport sur les variations periodiques des glaciers des Alpes suisses. Jahrbuch des Schw. Alpenclubs, Vol. XXXIII, p. 249. Bern, 1898.

² Report of PROFESSOR FINSTERWALDER.

³ Reports of DR. SVENONIUS and DR. OYEN.

Spitzbergen.—The most important work on these islands is that of Baron de Geer, who has visited them several times. He finds from the maps and photographs that the glacier of Sefström has advanced about four kilometers since 1882, but at present seems to be retreating. On the other hand, the glacier of von Post has retreated slightly since 1882. Sir Martin Conway found that the glacier, which he called the Ivory Gate, has advanced very considerably since 1870. The best accounts of the observations of Sir Martin Conway's party are found in the *Geographical Journal*, April 1897, and in the *Quarterly Journal of Geology*, 1898, Vol. LIV, pp. 197–227.

Dr. A. Hamberg has written on the parallel structure of glaciers. He thinks that this, as well as the similar structure observed in Antarctic ice, is due to stratification.¹ He thinks, also, that the movement of these glaciers is due to the slipping of successive layers over each other, and that there is practically no differential movement in the layers themselves. Dr. Hamberg thinks that in these latitudes greater pressure is necessary to convert the névé into solid ice than in warmer climates, and he thus explains the fact that many of these glaciers are not very thoroughly consolidated.

Franz Josef Land.—Dr. Nansen tells us, in the account of his celebrated polar expedition, that there are no true glaciers on these islands, but that they are covered with masses of ice sloping toward the sea. These are apparently of the same type as those described by Dr. Hamberg. Dr. Nansen also tells us that he found indications of the existence of a former glacier all along the northern coast of Siberia. He also gives us interesting descriptions of the folding and crushing of the polar ice as a result of ocean currents.²

Greenland.—A Danish expedition visited the island of Disco in 1897 and examined the glaciers of Blösedalen, which had been visited in 1894 by Professor Chamberlin. They found that

¹REV. O. FISHER gave the same explanation of the horizontal markings in Antarctic ice. *Phil. Mag.* (5) 1879, Vol. VII, pp. 381–393.

²Report of PROFESSOR NATHORST.

the two southern glaciers on the western side of the valley have made a marked retreat in the interval, and they established stations for the future observations of these glaciers.¹

Caucasus.—In this region a very large number of glaciers have been examined and photographed. They show a marked state of retreat.

Turkestan.—Twenty-six glaciers have lately been discovered and described by Dr. Ivanow in the mountain chain of Talassk-Alataou. They all have a great altitude and show indications of such a great retreat that they may perhaps disappear altogether. Many new glaciers have been examined and photographed in the mountain chain of Peter the Great. They are apparently in a marked state of retreat.

The Altaï.—Professor Sapojnikow has discovered in the last few years five glacier centers in the Altaï mountain. These contain more than thirty glaciers, some of which compare in size with the largest glaciers of the Caucasus. All of them are evidently retreating, but it is not yet possible to give even an approximation to the rate.²

A very interesting and full account of our present knowledge of Arctic glaciers and their variations has been published by M. Charles Rabot, under the imprint of the International Committee on Glaciers.³ After a short account of the characteristics of Arctic glaciers he takes up in detail various glaciers, with references to original sources of information, with the following results.

The glaciers of Grinnell Land appear to have attained a maximum shortly before 1883.

The inland ice of Greenland seems at present to be at a maximum, particularly in the north. In the south a slight retreat is showing itself but too slight to arrest the general advance of the ice which has been going on during the historic period.

¹ Report of DR. STEENSTRUP. DR. STEENSTRUP went back to Greenland in May 1898 to continue the study of the glaciers there, which he discontinued in 1880.

² Report of PROFESSOR MOUCHKETOW.

³ Les variations de Longueur des Glaciers dans les Regions Arctiques et Boreales, Archiv. des Sciences phys. et nat. Geneva, 1897, Vol. III.

The glaciers of Iceland began to advance at the end of the seventeenth century, at which time they were much smaller than at present. This advance continued, interrupted about the middle of the eighteenth century by a hesitating retreat in the case of certain glaciers. After this, most of the glaciers made an extraordinary advance; a veritable invasion of the ice took place, which continued during the larger part of the nineteenth century. After this advance there was a general retreat, though some glaciers are still advancing. The retreat began earlier in the north (1855 to 1860) than in the south (1880). It is less marked than the preceding advance.

There is a large volcano on Jan Mayen Land on which are nine large glaciers. A study of the records of whalers and explorers seems to show that these glaciers have advanced since the end of the seventeenth century.

REPORT ON THE GLACIERS OF THE UNITED STATES FOR 1898¹

The end of the Eliot glacier on Mount Hood, Oregon, is supported by its lateral moraines, and is much covered with débris. On each side, one or two hundred yards from the end, the ice seems to be breaking through these moraines. This may be due to stream erosion, washing out the moraines and thus removing the support for the ice; or it may mean the beginning of an advance (*H. D. Langille*).

Professor Russell has recently published a most interesting account of the glaciers of Mount Rainier.² He describes the characteristics of a system of glaciers on a conical peak. Starting in general from a common névé region the glaciers separate into distinct streams lying in deep channels. The V-shaped intervals between them are occupied by smaller glaciers, which he has called inter-glaciers. He thinks the amphitheatres at the

¹ The synopsis of this report will appear in the Fourth Annual Report of the International Committee. The report on glaciers of the United States for 1897 was given in this JOURNAL, Vol. VI, pp. 475, 476.

² The Glaciers of Mount Rainier, Eighteenth Annual Report of the U. S. Geol. Surv., pp. 349-423. A preliminary note on PROFESSOR RUSSELL'S observations appeared in Variations of Glaciers, II.

head of some of the glaciers are the result of glacial erosion; he gives also an interesting account of dome-shaped elevations, much broken with crevasses, which seem to be a peculiarity of these glaciers; they are apparently due to elevations in the bed of the glacier. Professor Russell describes all the glaciers except those on the western side of the mountain. He finds them all very much covered with débris at their lower ends, and notes that there is a general retreat. At one point he noticed that the surface of the Cowlitz glacier, about two miles from its lower end, has recently been lowered seventy-five to a hundred feet, as indicated by fresh lateral moraines deposited on the mountain. The Carbon glacier has receded about one hundred yards between 1881 and 1896, and the Willis glacier about five hundred feet in the same interval. All the other glaciers show a marked diminution, but the amounts were not determined.

Professor Russell has kindly sent me the following account of the glaciers in the state of Washington, which he saw in 1898. It will be noticed that their number is far greater than had been supposed.

Glaciers on the Wenatchee Mountains.—In examining the records of the old glaciers of the state of Washington it was found that the Wenatchee Mountains formed an independent center of ice dispersion from which flowed several large glaciers. One is not surprised, therefore, to find small glaciers still lingering on the higher portions of this rugged and exceedingly picturesque group of granite peaks.

On the summit portion of the Wenatchee Mountains about four miles due east of the culminating pinnacle of Mt. Stuart, there is a glacier measuring by estimate one mile from north to south, including both névé and true glacial ice, and of somewhat less width. It lies on the highest portion of the western rim of a magnificent amphitheater excavated in compact granite. A view into this desolate but wonderfully attractive basin, from the narrow crest forming its eastern wall, is the finest and most instructive picture of its kind to be found in the entire Cascade region.

On the north side of Mt. Stuart, about one thousand feet below its summit, which rises 9470 feet above the sea, there are three small glaciers, situated in steep gorges or clefts in the granite, and sheltered by outstanding cliffs; combined, they would probably make an ice body less in mass than the one described above. These glaciers are narrow, and extend down the gorges where they occur for some two thousand feet. Below each there is a small and fresh-looking moraine.

The glaciers just described derive their main interest from the fact that they are isolated, being some twenty-five or thirty miles to the east of the main divide of the Cascade Mountains.

Glaciers on the Cascade Mountains.—The glaciers of the Cascade Mountains south of the United States-Canadian boundary probably number several hundred, and of these about 100 or 150 have been seen by the writer; but only a few, in the immediate vicinity of Glacier Peak, have actually been traversed. All of them are small; of those seen, probably the largest is not over two miles in length, and by far the greater number are considerably below this measure. Nearly all lie in amphitheaters or cirques. Their principal interest centers in their distribution, their relation to climatic conditions, and the fact that all of those seen are accompanied by evidences of recent recession.

There is one small glacier, however, that is worthy of special study in reference to the manner in which an ice-stream expands when not confined by walls of rock, and in expanding, forms longitudinal, or perhaps more properly, radial crevasses in its fan-shaped terminus. The glacier referred to is at the head of White Chuck Creek at the immediate south base of Glacier Peak, but on the south side of the deep canyon in which flows the branch of the creek nearest to the base of the peak. This glacier flows northward, and is in full view from Glacier Peak. The periphery of its broadly expanded extremity is not over 1000 or 1500 feet by estimate, and is broken by some four or five radial crevasses which are widest on the outer margin of the fan-shaped expansion and contract to narrow clefts which become still smaller, and disappear when traced toward the feeding *névé*.

This is a typical miniature example of glaciers like the Rhone glacier, Switzerland, and the Davidson glacier, Alaska.

Most of the glaciers on the Cascades have a lower limit of about six thousand feet; the majority of them are west of the Cascade divide, and are either in immediate proximity to or on Glacier Peak and the sides of lateral ridges branching from it; or else on somewhat detached peaks, some of them ten to twenty miles west of the Cascade divide. Of these outlying groups of glaciers, the most numerous are at the heads of high grade valleys in the granitic peaks about Monte Cristo, as has been observed by Bailey Willis, and on similar granitic peaks bordering the upper course of Skagit River. There is also an outlying group of glaciers on Mt. Baker and neighboring mountains.

The broadest névé fields and most numerous glaciers occur on Glacier Peak and the rugged mountains surrounding it. The snow fields in this region cover a rugged area some ten square miles in extent, and are confluent; from this gathering ground there flow several short ice streams, or rather ice tongues, as none of them have a characteristic stream-like form. The névé extends up the sides of the culminating cone of Glacier Peak and occupies the remnant of a crater still recognizable at its summit. From the top of Glacier Peak fully fifty glaciers are in view within a radius of about thirty miles. But little, if any, difference in the distribution of these glaciers can be recognized, on looking northward or southward, thus indicating that their existence depends rather on general climatic conditions, than the occurrence of previously formed cirques, or the shelter afforded by lofty peaks.

Lituya Bay, Alaska.—This bay was visited and mapped by La Pérouse, in 1786. It has the shape of the letter T. The cross arm of the bay was not surveyed but was drawn in from descriptions of the officers who visited it. La Pérouse speaks of five large glaciers coming down to the water, two at each end and one at the side of the cross arm. The maps of the Canadian Boundary Commission, made about 1894, show that the side glacier has diminished, but that the two glaciers at each end of

the bay have coalesced and advanced nearly two miles (*O. K. Klotz*).

Dr. William H. Dall, who visited the bay for the United States Coast Survey, in 1874, thinks that these glaciers were certainly a mile or more shorter then than the Canadian map shows them to be now; so that the advance seems to be still progressing.

Mexico.—The glacier on Mount Iztaccihuatl is advancing (*Ez Ordoñez*).

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